## *PROFESSOR MENDELÉEFF ON THE HEAT OF COMBUSTION.*[1]

DULONG'S formula, which gives the heat of combustion of different solid and liquid fuels, as depending upon their composition, is, as is known, $\phi = 81\,c + 345\left(h - \frac{o}{8}\right)$, $c$, $h$ and $o$ representing the percentages of carbon, hydrogen, and oxygen in the fuel.

If a general expression, $\phi = \mathrm{A}c + \mathrm{B}h - \mathrm{C}o$, be taken, the numerical value of the coefficient $\mathrm{A} = 81$ must be maintained, because it corresponds to pure charcoal, and all known data (from 8140 to 8060) prove that the figure 81 must really be taken for each per cent. unit of carbon in the fuel (the accuracy of the measurements being within the limits of from 1 to 2 per cent. of the total heat of combustion). For hydrogen, however, the coefficient $\mathrm{B} = 345$ cannot be maintained, because it has been obtained out of data relative to the burning of gaseous hydrogen, while in usual solid or liquid fuel the elasticity of the gas is lost; its hydrogen must be considered as if it were liquefied, and consequently B must not be, according to what is known, more than 300 (admitting, as is usually done, that the water obtained during combustion is in a liquid state).[2]

In order to find the true coefficients suitable for practical purposes, Mendeléeff took the figure $\phi = 4190$, which is quite correct (within 1 per cent.) for pure cellulose, as also the average from 79 most complete measurements for fat coals (by Maler, Alexeyeff, Damski, Diakonoff, Miklaschewski, Schwanhöfer, and Bunge), and the average for naphtha fuel, and he has found:

$$\phi = 81\,c + 300\,h - 26\,(o - s),$$

which formula represents,[3] with an accuracy of from 1 to 2 per cent., the heat of combustion of pure charcoal, coke, coals, lignites, wood, cellulose, and naphtha fuels; of course, it applies to the best determinations only, especially to those which were made in a calorimetric bomb, where the error is less than 1 to 2 per cent.[4]

This formula is an approximate empirical expression of facts; but it corresponds at the same time to the numerical value of the coefficient B for hydrogen, which could be expected from theoretical considerations.[5]

## *THE SCIENTIFIC REQUIREMENTS OF COLOUR PHOTOGRAPHY.*

ON Tuesday evening, June 1, in the Examination Schools, Oxford, Captain W. de W. Abney, C.B., F.R.S., gave the sixth Robert Boyle Lecture before the Oxford University Junior Scientific Club. The President, Mr. R. A. Buddicom, was in the chair, and about 800 members and their guests were present.

The subject chosen by Captain Abney was "The Scientific Requirements of Colour Photography." The following is an abstract of the lecture:—

Colour photography and photography in natural colours are two distinct methods of arriving at the same end, namely, the production of a picture of objects, coloured as they naturally appear to the eye. Both have been accomplished and depend on the application of science, but in the case of the former additional knowledge is requisite of the mode of action of the retina and of theories of colour vision.

In colour photography the theory of colour vision usually adopted is the Young-Helmholtz three-colour theory, in which red, green and blue are selected as primary colours, and not the red, yellow, blue of the artist. Captain Abney pointed out the difference between colour and colour sensation, and placed his colour sensation curves before the audience. These curves enable particular coloured screens to be selected, so that if transparencies from three photographs of the same object, taken one through an orange screen, one through a green, and one through a blue, be each illuminated by its own peculiar coloured light, and the three images be superimposed, the effect is to reproduce a picture of the object in its original colours. The colours of the screens used for taking the negatives must not be such as to allow only monochromatic light to pass. Thus the red screen must allow some orange, the green some yellow, and the blue some green, so that the lights through the three screens overlap somewhat.

The viewing screens, on the contrary, should be as nearly monochromatic as possible. By these means Mr. Ives has, in his chromoscope, been able to present to view photographs of natural objects in the colours in which they appear to the eye.

The next process described was that of Dr. Joly, of Dublin, who, basing his work on the same theory of colour vision as Mr. Ives, reproduces in colour by means of a single negative. This method is essentially founded on what may be called a happy imperfection of the eye. The human eye is incapable of separating points which lie very close to one another. In an engraving, the black lines, close together on a white surface, blend with the white surface to form shades of grey. Dr. Joly's method is to rule lines 1/200 inch broad on a transparent screen, touching one another and being coloured alternately red, green and blue. The lines are of such a depth of colour that the mixture, if made by rotating sectors, would appear white or grey. This screen is used for viewing. To make the negative another exactly similar screen is placed in front of the plate, but the colours of the lines on this differ, just as Mr. Ives' coloured screens for taking the negatives differ from his viewing screens.

When the negative is taken, a transparency is made from it, and the viewing screen is placed behind it, so that the red line covers the place through which the orange negative was taken, and so on. Then, and not till then, the picture appears in its natural colours.

Instead of using transparencies and coloured films, transparent inks may be used to produce pictures by three printings.

The next process described was the oldest, namely, the production of colour by the action of light itself. The present year is its jubilee. Becquerel found that if, instead of iodising a plate, he chlorinised it, and then exposed it to white light, it gradually assumed a violet tint, and if, in this state, he exposed it to the spectrum he was able to obtain the colours of the spectrum on it.

Abney, some years ago, showed that the red tint was due to the lavender-coloured material taking up oxygen, whilst at the violet end the subchloride became further reduced: thus the big molecules formed by the addition of the oxygen vibrated slower, whilst the abstraction of chlorine gave smaller ones vibrating quicker. Since he was able to get the same effect on collodion plates, it is not probable that the colours are due to stationary waves, because, if so, they could only be viewed by reflected light. Unfortunately, however, these colours, from the very manner in which they were produced, were not permanent, and no method has been devised for fixing them.

The last method Captain Abney described of obtaining photographs which showed colour, but not coloured photographs, was that of Lippmann, who found that if, by means of reflection, he obtained stationary waves in the film, on development the silver was deposited between the nodes. On reflecting light from such a "noded" plate, the proper light alone was reflected, and the photograph, viewed at a particular angle, appeared in its natural colours. If looked at by transmitted light, these photographs have merely the appearance of ordinary negatives.

The proceedings closed with a vote of thanks to the lecturer, proposed by Prof. Burdon Sanderson, and seconded by Mr. A. F. Walden.

## *THE INTERNATIONAL CONGRESS ON TECHNICAL EDUCATION.*

THE International Congress on Technical Education, opened by the Duke of Devonshire at the Society of Arts on Tuesday, June 15, was continued on the three following days. Many important papers were read, and there was a large attendance of delegates from the continent and abroad. We have extracted from the *Times* the subjoined brief reports of a few of the papers read and the discussions which took place upon them.

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[1] Translated from the *Journal* of the Russian Chemical and Physical Society, vol. xxix. fasc. 2, 1897, pp. 144. (Minutes of meeting of February 18, 1897.)

[2] Maler has also adopted that coefficient, taking $\mathrm{C} = 30$.

[3] The percentage of sulphur was not determined in each measurement, and consequently the coefficient $+26$ is determined only approximately.

[4] If the water which is formed during combustion is represented, as it is in reality, in the shape of steam, then 600 $aq$ must evidently be deducted from $\phi$; $aq$ representing the weight of water obtained from the combustion of one unit of fuel.

[5] In those cases where different values of $\phi$ were received for the same composition of coal, the discrepancies could be explained by errors of measurements; there was no foundation to suspect isomerism. A good deal of the now prevailing incertitude is also due to the incomplete data relative to the amount of combustible sulphur.

Several papers on the aims of instruction in chemistry were read on the opening day. In one paper Dr. Otto N. Witt, Professor of Chemical Technology at the Polytechnic School of Berlin, said he could not admit any fundamental difference in the methods of research of pure and applied chemistry, consequently he could not admit the necessity for a difference of instruction for the two. A well-organised instruction in pure chemical science would, in his opinion, be the best preparation of any young chemist for his future career. He held that schools for producing specialists were not wanted; for specialism came as a matter of course in later life. Chemists were needed who embraced their science as a whole, and who were incapable either of separating practice from theory or theory from practice.

Dr. H. E. Armstrong urged the need of better organisation in regard to instruction dealing with the preparation of the soil for agricultural purposes.

Dr. Gladstone, in the course of a paper on "The Teaching of Chemistry in Evening Continuation Schools," said that when the evening school was situated in the neighbourhood of factories it would be allowable and even desirable that the illustrations should be chosen with some reference to the prevailing industry.

Sir H. Roscoe, in opening a general discussion on the subjects dealt with in the foregoing papers, pointed out that what we in England suffered from was the failure of our manufacturers to see, as they ought to see, the importance of the highest scientific training for their *employés*. Recently he visited some large colour works near Frankfurt, where 100 men were employed, including many highly-trained scientific chemists who had devoted years to original research with a view to making new discoveries. One *employé*, who received 1000*l*. a year, worked for several years without producing any results. But eventually he made a discovery which repaid the firm ten times over and placed an entirely new branch of manufacture in their hands. Scientific teaching had taken up a sound position already, and if manufacturers would only appreciate its value we could turn out scientific men as well as any country in the world.

This view was given support by a paper on "The Teaching of Chemistry," by Prof. G. Lunge, of Zurich, read by Sir H. Trueman Wood. The writer held that, to raise English chemical industry to the foremost rank (which was disputed to it at present in several important branches), it was necessary that the technical management of chemical factories should not be left in the hands of "rule-of-thumb" men, but should be intrusted to real chemists. These men should have a much fuller education than the majority of chemists seem to obtain at present in Great Britain, which meant that they must spend more time and money on their training than they generally did. At college the student should receive a thorough training in scientific chemistry, taking this in its widest meaning, not merely as a "testing" exercise. Next to this, but not to the same extent, he should be taught physics, mineralogy, technology, mechanics, and the elements of engineering. As to whether foremen or even the common workmen should possess a certain knowledge of chemistry and technology, such as may be imparted at Board schools or at night classes for adults, Prof. Lunge was afraid that such knowledge was quite useless to ordinary workmen, who had simply to do as they were told, and who might do more harm than good by trying to apply a superficial idea of the nature of the operations which they had to perform, without possibly having a real insight into them. He did not even think that, apart from isolated exceptions, such knowledge was much good to the foremen, whose duty it was to carry out their instructions and to see that the men did their work as prescribed by the staff, but who were not to meddle with the chemical process itself.

Prof. Silvanus P. Thompson, in discussing the paper, said there should be a distinction between the different branches of the subject. He urged that where a great industry was localised science should be applied to that industry, and an institute should be put there devoted to monotechnical rather than polytechnical instruction. Training in research was absolutely necessary, and specific research should not be undertaken too soon by students who had not been taken through an all-round course in chemistry.

Mr. G. R. Redgrave, Chief Senior Inspector Science and Art Department, read a paper giving an historical retrospect of "The Intervention of State in Secondary Technical Education," in the course of which he urged that something of the nature of the German Realschule, but with a far larger proportion of practical science work and manual training, should be our model for the secondary school in this country.

On Wednesday, June 16, Sir Philip Magnus, in a paper on "Theory and Practice in Trade Teaching," referred to the difficulty of determining the true relation of theory and practice in teaching the technology of any trade, and in the Technical Instruction Act, which expressly forbade the teaching of the practice of a trade in any technical school. But in the great majority of industries the practice of the trade was best acquired in the factory and shop, and the instruction of the technical school should be supplementary only to the experience obtained in commercial work. By this principle nearly all our technical classes were regulated. Although a technical school might be equipped almost as completely as a trade shop the equipment served a very different purpose. Its object is the production of intelligent workpeople, and not the production of saleable commodities. The practice a student obtains in a technical school was intended to enable him to understand appliances of his trade, and to use them with care and judgment.

Mr. S. H. Wells, Principal of the Battersea Polytechnic, pointed out that the greatest of all difficulties in connection with technical classes was undoubtedly the provision of satisfactory and efficient teachers. The first and most natural qualification of a teacher of technical classes was that he should possess a practical knowledge—acquired in the factory or workshop—of the subject to be taught; the second, that he should possess a sound knowledge of the arts and sciences applicable to the subject; and the third, that he should be able to impart his knowledge to others, to arrange a syllabus of instruction, to manage a class, in a word, to teach.

Prof. Ayrton gave an account of the Central Technical College, South Kensington. He remarked that the facilities for technical instruction in London were increasing every day, but a system of coordination was greatly needed.

Prof. Silvanus Thompson urged the coordination of educational institutions from the highest to the lowest. Dr. Garnett said that if artisans were to be attracted to technical classes the teachers must be acquainted with the practical details of the trades to which the artisans belonged. It was difficult to find theoretical and practical knowledge combined in one man. The presence of practical workmen he had found a great advantage when holding his classes. Prof. Viriamu Jones (Cardiff) believed that artisans would ultimately avail themselves of the best instruction to be obtained in each science bearing on their trade. They would feel that teaching by specialists was better for them than teaching from those who might have learnt but little of the subjects. Mr. Reynolds (Manchester) pointed out the wasteful overlapping that prevailed in connection with technical instruction. The Technical Instruction Act, which forbade the practice of a trade being taught in technical schools, was practically a dead letter in Lancashire, and deserved to be. Prof. Chatterton (Madras) said that the great difficulty in connection with the technical schools in the Madras Presidency was to obtain efficient teachers. Mr. Mundella, M.P., said that proper elementary education was indispensable before working men could derive benefit from special technical instruction. Parliament must raise the limit of age for compulsory attendance at elementary schools to that which prevailed in other countries. If his students had not been well educated in elementary subjects the science master was called upon to make bricks without straw.

The Chairman; Major-General Sir J. Donnelly, in concluding the discussion, referring to the interpretation of the Technical Instruction Act, said technical instructors might teach how a thing was done, but not carry their training so far as to give the rapidity and dexterity of manipulative skill required for the craftsman or journeyman. Looked at in that way, there was no difficulty in working the Act.

Mr. Mundella, M.P., in introducing Prof. T. V. Diefenbach, to read a paper on "Technical Education in Würtemberg," referred to the marvellous progress made by the kingdom of Würtemberg during the last forty years. A commission from England, which visited Würtemberg to inquire into their system of technical education, reported that they had seen no part of Europe more progressive than Würtemberg, and they were assured that there was not a single pauper in the whole country. He wished he could say the same of England.

Sir Joshua Fitch then read a paper on "Some Limitations to Technical Instruction," in which he entirely admitted that our school instruction had long been too bookish, too little practical, and that the friends of technical instruction were fully justified in calling attention to the grave deficiencies in our system, especially to the want of sounder teaching in physical science and of better training in the application of those sciences to the enrichment of the community and to the practical business of life.

Prof. Oscar Pyferven, of the University of Ghent, who represented the Belgian Government, read a paper on "L'Enseignement Professionnel et l'Initiative Privée en Belgique"; and M. E. Sève (Consul-General for Belgium) read a paper on "Technical and Commercial Instruction in Belgium."

Prof. Wertheimer, principal of Merchant Venturers' Technical College, Bristol, read a paper on the influence of various examining bodies on the progress of technical and commercial education in England. He held that it behoved them to watch closely any attempt to establish new examinations. The technical instruction committees of some County Councils were already instituting examinations of their own; in a very few cases these might be necessary to meet special local requirements. But, as a rule, they were not needed, and it would be wiser to endeavour to modify existing examinations, if necessary, rather than to establish new ones.

On Thursday a paper by Mr. Quintin Hogg, on "Polytechnics," was read by Dr. William Garnett, who also gave an account of the work of the Technical Education Board of the London County Council. In commenting upon the latter paper, Sir John Lubbock said that too much of the money went to the elementary and too little to the higher training of those who were to be the leaders of industry.

The next paper was on "Reforms in the Organisation of Technical Education," by Prof. Silvanus P. Thompson, F.R.S., who said that the provision made on the continent for the higher training in chemistry might be understood from the fact that the entire establishment of the Regent Street Polytechnic, chemical laboratory, gymnasium, swimming bath, theatre, kinematograph, and all, might be accommodated within the space provided for the chemical laboratory alone in the polytechnic at Munich. The chemical laboratory of the polytechnic at Zurich exceeded in contents the whole of the technical schools at the People's Palace. The chemical laboratory of Berlin was larger than the whole building of the City of London College. The physics laboratory at Zurich was considerably larger than the whole building of the Finsbury Technical College, and the cost nearly twice as much.

The remainder of the papers on Thursday dealt with commercial education, the organisation of examinations, and the development of technical instruction in secondary schools.

The concluding session of the conference, held on Friday last, was devoted exclusively to the consideration of papers by ladies on a variety of aspects of technical and secondary education. Mr. Mundella, M.P., presided.

Miss Alice Mitchell read a paper on the "Teaching of Domestic Economy in Girls' Secondary Schools." In the high schools she thought the great failure was the absence of the practical side, for all schools suffered from the want of laboratory facilities.

A paper was read by the Countess of Warwick on "Technical Education in Rural Districts." She said she had undertaken the task believing that a careful development of the subject might help not a little to stay the depopulation of our villages. An intelligent appreciation of natural phenomena and natural laws, when applied to agriculture, might go a long way to relieve the depression from which country districts were so keenly suffering. The elements of chemistry and physics, geology, botany, and zoology might be taught with great advantage to the future farmer or practical agriculturist. We should no doubt some day have a rational system of education, and not a disjointed one, as at present, when due regard would be paid to the co-ordination of subjects of instruction. At present, the great want was co-operation in all branches, but this was likely to remain while every branch of education was under a separate and distinct authority, often antagonistic to each other and encroaching on one another's grounds. In the same town they might see the voluntary schools, board schools, middle schools, grammar schools, and technical classes all being carried on under separate rate authorities, who have no regard for each other's work, and consequently overlapping each other's efforts, in many directions leading to waste of time, money, and energy. District technical schools should be opened within given areas, or a technical side to existing schools be developed; or, perhaps better still, the schools of the whole district should be affiliated, with a technical school attached, for the use of the pupils from all. The money received by county councils for the technical education grant might be well spent in equipping such schools. If a plot of land could be attached to the technical schools, it would be very useful for the purpose of experiment and demonstration in the field.

At the close of a discussion, the Chairman said Lady Warwick's paper was so full of suggestions that it was impossible to comment upon them briefly. It involved educational reforms of the highest importance, and the first was that one public authority in each district should see that education was properly carried out. Lady Warwick had put aside the utilitarian view; nevertheless, this was a subject of considerable moment, both in town and country. Denmark was far ahead of us in agricultural matters, and sent to this country produce to the value of 10,000,000*l.* annually. It was an extraordinary thing that we should have to pay enormous sums of money to foreign countries for supplies which we ought to be able to provide much better at home. They were told that foreigners were more intelligent than our people; and although he did not believe that, we should educate our people and try to make them as intelligent, fruitful, and productive as their foreign competitors.

A large number of other papers were read before the Congress, but the limitations of space prevent us from referring to them.

## SCIENTIFIC SERIALS.

*American Journal of Science*, June.—Bacteria and the decomposition of rocks, by J. C. Branner. In criticism of the somewhat largely prevailing idea that bacteria are the cause of much of what is called the decay of rocks, it must be remembered that nitrifying bacteria not only do not penetrate the rocks themselves to any considerable depth, but they do not even penetrate the soil to a depth of more than three or four feet. Granites are, on the other hand, often decomposed to depths of more than 100 feet.—On Wellsite, a new mineral, by J. H. Pratt and H. W. Foote. This mineral occurs at the Buck Creek corundum mine in Clay Co., North Carolina, associated with albite, felspar, and hornblende. No crystals found exceed 2 mm. in length. They are monoclinic and twinned, brittle, with a vitreous lustre and no apparent cleavage. They are colourless and transparent or white, with a hardness of between 4 and 4·5, and a density of about 2·3. Chemically, it is a barium or calcium hydrated silicate corresponding to the formula $RAH_2Si_3O_{10}.3H_2O$, and is therefore allied to Phillipsite, harmotome, and stilbite.—The magnetic increment of rigidity in strong fields, by H. D. Day. The author employs extremely strong fields in order to bring out clearly the relation between magnetisation and the phenomena of magnetic rigidity. He shows that long after magnetic saturation has been reached the increase of rigidity due to increase of field intensity goes on, and that the limit of the latter is not reached even with the highest field intensities attainable. As the field becomes stronger, the increment of rigidity varies more and more regularly with the twist, the tendency being that in fields indefinitely large the increment of rigidity would be proportional to the twist applied.—The broadening of the sodium lines by intense magnetic fields, by A. St. C. Dunstan, M. E. Rice, and C. A. Kraus. The phenomenon of the magnetic broadening of the sodium lines discovered by Zeemann may be easily observed with the aid of Michelson's interferometer. Light from a Bunsen flame containing a sodium salt is sent on to a plate of plane glass which partly reflects and partly transmits it to a fixed and a movable mirror. The fringes produced in the telescope by their recombination are made less visible by the broadening of the line observed. The curve of visibility gives the amount of the broadening. In the most intense field the broadening is in the ratio of 1 to 1·7. It is proportional to the field intensity.—The relative motion of the earth and the ether, by A. A. Michelson. This was investigated by an interference experiment in which a beam of light was made to travel round a rectangle in a vertical E. and W. plane, and to return along the same path. If the ether near the earth's surface moves with the earth, and the ether above the atmosphere is stationary, there must be some difference of